

**THE AUTONOMOUS GRID:**  
Machine Learning  
and IoT for Utilities





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# Introduction

**Machine learning** and the **Internet of Things (IoT)** are two of the hottest terms out there today for utilities. Both have the power to create an increasingly autonomous grid that can eventually handle billions of endpoints on utility networks, but the industry may not be maximizing the benefit of these disruptive innovations, nor adequately leveraging the connection between the two of them.

To better understand the progress being made in the utility industry, SAS and Zpryme reached out to 200 North American utilities through online surveys and phone interviews to learn more about their approaches toward IoT and machine learning.

This paper explores:

- How utilities are using IoT and machine learning today, as well as their plans for the future
- The utility industry's understanding of IoT and machine learning
- Recommendations for utilities to improve their abilities to adopt these technologies on a larger scale

Key findings include:

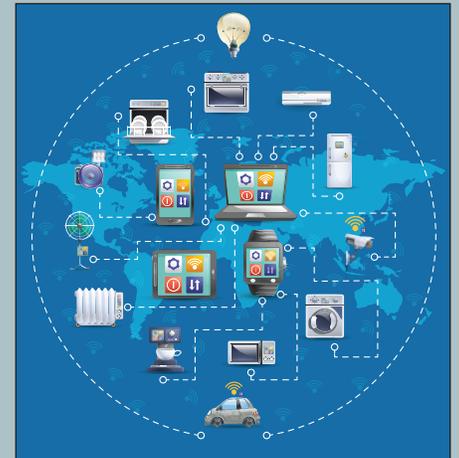
- Utilities agree that both IoT and machine learning are critical for their organizations, but they have a better understanding and are more likely to be using IoT than machine learning.
- More than 55% already use IoT for metering/meter data management (MDM), and 31% are already using machine learning for this area, too.
- Network security and data privacy are major IoT concerns for utilities. Areas of least concern are lack of expertise and sufficient budget.
- The top benefits associated with IoT are more likely to be customer-facing, such as customer service and energy efficiency, whereas the benefits named for machine learning are more grid-oriented, including areas such as service restoration and cybersecurity.

## DEFINING THE TECHNOLOGIES



### **Machine learning**

Machine learning is a method of data analysis that automates analytical model building. Using algorithms that iteratively learn from data, machine learning allows computers to find hidden insights without being explicitly programmed where to look.



### **Internet of Things (IoT)**

The Internet of Things is the concept of everyday objects—from industrial machines to wearable devices—using built-in sensors to gather data and take action on that data across a network.

# Drivers to Invest in an Autonomous Grid



IoT devices are flooding our world. Gartner forecasts that 6.4 billion connected devices will be in use worldwide in 2016—up 30% from 2015—and will reach 20.8 billion by 2020. In 2016 alone, 5.5 million new devices will be connected each day.

For utilities, the smart grid era unleashed not only millions of these new IoT devices, but also more data that utilities need to analyze and understand to make better decisions about their networks.

“There are going to be so many IoT devices out there that we’ll have to develop machine learning or analytics that can take into account the sheer volume of data,” said Kevin Lagge, Director, Strategy, Analytics, Enterprise Architecture and Technology Planning, Oklahoma Gas & Electric (OGE). “It’s critical, from the standpoint of the volume of information we’re going to have in the future, that machine learning is developed. We’re not going to be able to have a human interface every time we want something to improve.”

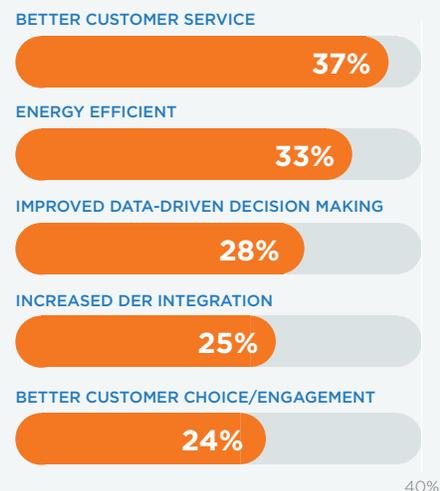
Machine learning and IoT will enable utilities to better realize the next generation of the grid rapidly coming at them: a distributed system with power flows among millions of things like distributed energy resources (DERs), microgrids and in-home devices. All of which will help utilities deliver more reliable energy and greater customer choice.

When asked about the benefits of investing in IoT and machine learning—we asked respondents about the exact same list of benefits for each—utilities selected better customer service as one of their top five benefits for both tools. (Figures 1 and 2)

Where the benefits diverge is that IoT excels at connecting all those devices, particularly at the customer level—including better integrating DERs and improved customer engagement—whereas machine learning shines when it is strategically applied to analyze, adapt and learn from data coming from those connections.

Machine learning goals focus more on using analytics to optimize the complexity of these vast, vulnerable networks of sensors. The top machine learning benefit for utilities is increased cybersecurity (39%), but not far behind is improved data-driven decision making, reduction in restoration time, and increased grid visibility/control.

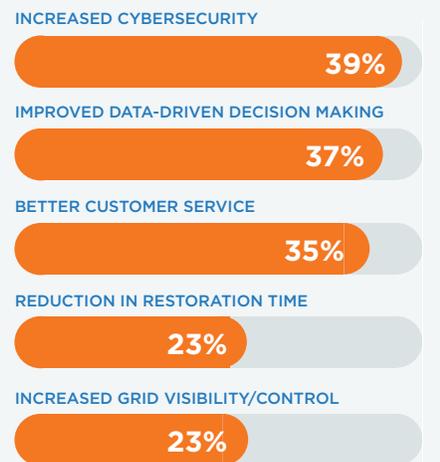
**Figure 1.** Top five IoT benefits



40%

Note: Percentage of respondents that placed these benefits in their top three

**Figure 2.** Top five machine learning benefits



40%

Note: Percentage of respondents that placed these benefits in their top three

# An Unequal Playing Field

Utilities that participated in this research agree that IoT and machine learning are important trends. And, in fact, few believe that they are overhyped concepts. (Figure 3) The most significant opportunity for growth is to understand how machine learning can contribute to the utility business.

A closer look at the differences between the IoT and machine learning viewpoints aligns with common technology adoption bias. The most hyped products—in this case, the often physical products related to IoT—are easier to justify an investment in than the unseen algorithms, even if they are the “brains” of the entire operation.

The research showed a statistically significant difference in responses to these same questions across IoT and machine learning categories, indicating that utilities have a better understanding of, and are more likely to be using, IoT technologies than machine learning capabilities today. And while utilities generally lack comprehensive strategies around these areas, IoT is more likely to have a defined strategy than machine learning.

IoT is ahead of machine learning in terms of familiarity and adoption in utilities, but it is important to consider both as a partnership for delivering a more self-sufficient grid.

“I think they’re very, very linked,” said Raiford Smith, Vice President, Corporate Development and Planning, CPS Energy. “You can have one without the other, but they feed off each other.”

How well are IoT and machine learning working together for utilities? And how do utilities view their importance within their organizations? We’ll take the next few pages to explore these questions.

MACHINE LEARNING IS NOW REALITY

As early as 1959, Arthur Samuel defined the concept of machine learning as the ability of computers to learn to function in ways that they were not specifically programmed to do.

The philosophy behind machine learning is to automate the creation of analytical models in order to enable algorithms to learn continuously with the help of available data.

Machine learning can be applied in cases where the desired outcome is known (guided learning), or the data is not known beforehand (unguided learning), or the learning is the result of interaction between a model and the environment (reinforcement learning).

Source: “Applying machine learning to IoT data” [http://www.sas.com/en\\_us/insights/articles/big-data/machine-learning-brings-concrete-aspect-to-iot.html](http://www.sas.com/en_us/insights/articles/big-data/machine-learning-brings-concrete-aspect-to-iot.html)

**Figure 3.** IoT versus machine learning: Understanding and adoption



# Machine Learning and IoT Use Cases



Utilities see the importance of and plan to use these capabilities, but where and when will IoT and machine learning really take off?

When we asked utilities where they plan to use IoT and machine learning, we found a wide range of use cases that utilities listed as actively underway now or within the next few years.

This is likely, in part, because IoT and machine learning are really an outgrowth of the smart grid and data analytics efforts we've seen over the past several years.

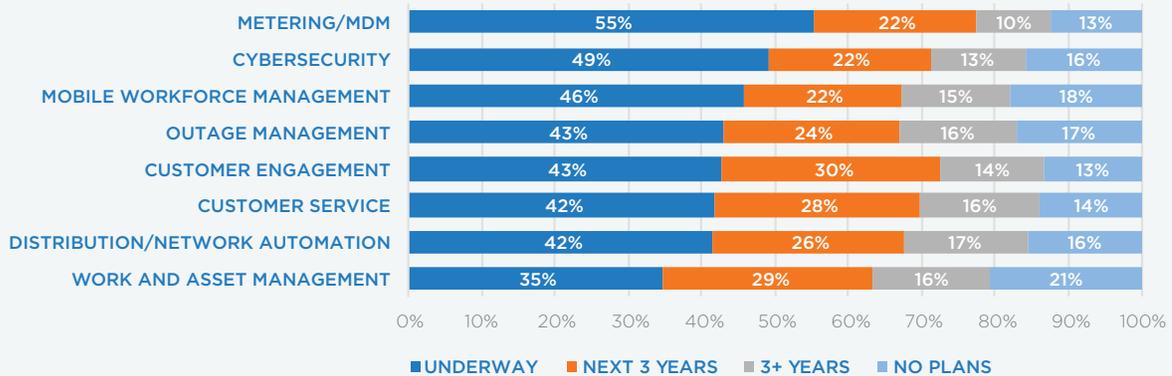
Figures 4 and 5 show that advanced metering and MDM are starting points for both technologies since

these areas offer utilities the ability to experiment more with new technologies. More than 55% of respondents already use IoT for metering/MDM and 31% are using machine learning in the area.

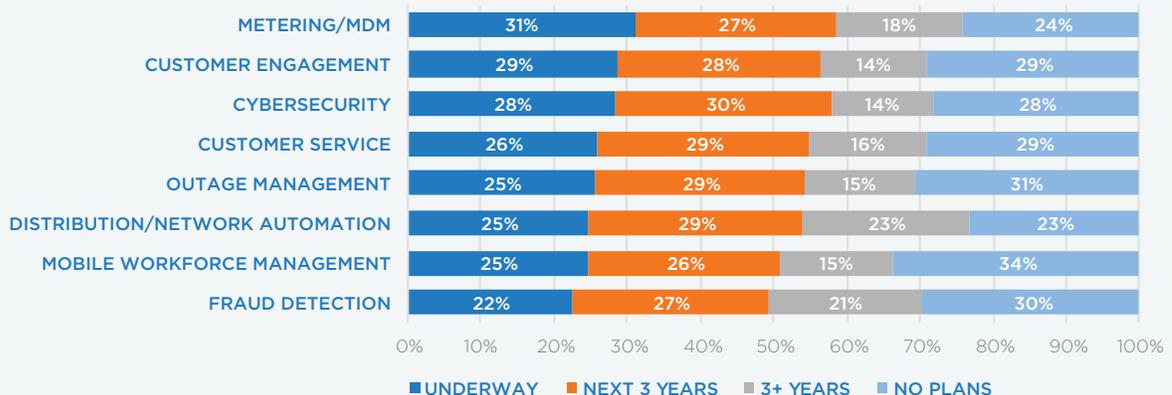
Utilities appear to be further along with the implementation of the connected devices and software that constitute IoT. However, most plan to utilize both machine learning and IoT within their organizations within the next few years.

On the following pages, utilities give real-life example of their current and planned uses of machine learning and IoT.

**Figure 4.** Use of IoT for key utility areas



**Figure 5.** Use of machine learning for key utility areas



# Utility Examples of Combining IoT and Machine Learning



Utilities participating in our research identified several areas ripe for greater analysis and autonomy. Below are a few examples of how utilities are applying or planning to apply machine learning to IoT data.

## Demand response events

“One of the primary ways we’re using machine learning is to better fit demand response events. We go through a process to determine what the customer’s baseline is and how they actually performed. We’re using machine learning to come up with a better baseline. That’s really our first foray into it. We expect once we’ve done it, and get good results from it, we can apply it in other places. We have a roadmap for all of our major business units, and there are a number of different use cases where we think we can apply that technique in order to get some good value for the company.”

“This is a system which we’re just now starting to bring up that would enable customers to participate with us in operating the grid so that it’s an interactive platform. That’s something where we’ll be able to communicate and determine when we need to have curtailment or need to reduce load, and we can do that in a specific area. In the past, that was a manual process where we would actually send out communications via phone or email, and announce we’re going to do it. We’d have a contractual relationship, and then we’d ask for curtailment and that would be done system-wide. With this new platform that’s being designed, it will be something which enables us to operate in a real-time fashion.”

## Asset optimization

“Where we’re using the neuro-learning is in a lot of our areas in forecasting...When you take a look at our risk management optimization center, we have put a lot of time and energy into the algorithms and developing the basis for how all of the data and the logic tie together. We do see a future where you can apply that neuro-learning into it...We have built into our algorithms—we’ll call it industry intelligence—the factors we look at when predicting the probability of failure. And so, if you have not just your own equipment history, but you have industry knowledge about what type of things had premature failure or may have design concerns that we can build into our algorithms.”

## Outage management

“Our outage management system has a significant amount of analytics that determine what the outage is, where it is, and how fast we need to respond to outages. Now, most of what we’re doing today is analytics-validating models and learning from them with a lot of human interface and some automated interface. We want to be able to identify outages faster and even predict them, and then prevent them from happening or fix them faster. We want to manage our resources more effectively at the same time. That’s the whole effort—to reduce downtime and improve reliability at a lower cost. That’s where machine learning and the automating of devices are going to have the biggest impact on us.”

## Customer engagement

“We’re going to have to mine of all this data that we’re going to get from adding devices onto the distribution system. This will help us know how the customer behaves, and how their structures behave. What are their wants and likes for different services and offerings that we might be able to offer in the future? Those are just all opportunities for machine learning.”

# Concerns



Utilities are moving toward IoT and machine learning, but there will be challenges as they increase the adoption of these capabilities across the enterprise.

Respondents rated how concerned they are with several aspects of IoT and machine learning—a “1” rating signals that it is not a concern and a “5” indicates a significant concern. Network security and data privacy are significant IoT concerns for the utilities in this study. (Figure 6) These concerns aren’t necessarily excuses to avoid IoT, particularly given the expected benefits, but they point to important areas that utilities must manage effectively.

Other concerns that resonate for both IoT and machine learning include:

- Delivering expected business value
- Lack of expertise
- Sufficient budget

These concerns aren’t surprising. As with any new technology, companies are concerned about whether these technologies will be able to deliver on their promise because they haven’t been tested at a significant scale.

What is surprising is that lack of expertise and sufficient budget are not the top concerns. These are typically the biggest concerns that organizations have with analytics in general.

As utilities reap benefits from machine learning and IoT, constrained budgets and expertise may rise in importance as they seek to expand capabilities.

“Part of the challenge is expertise, and then part of it is partnerships. In the talent area, we do not have a lot of experience,” said Randy Vance, eServices Manager, Kansas City Power and Light (KCPL). “A lot of competitive industries may have data scientists onboard, but that’s not a standard job description here. I think part of it is developing or attracting that

talent, but it’s also going to be very important that we make the right choices in terms of partners that can bring the expertise we’re lacking.”

These challenges will be addressed as IoT and machine learning move forward on more and more significant scales, and companies need to prepare for significant changes ahead.

“We need to take the step to prove out value,” said Jason Mann, Director, Product Management for Industry Solutions and Internet of Things, SAS.

“The next opportunity will be to demonstrate proof of these concepts—the technology is there, the data is there, the capability exists and now the next step is to prove it out.”

Figure 6. Top concerns about IoT and machine learning



# What's Next for IoT and Machine Learning



As these technologies move from pilot to production, expect to see significant changes for utilities.

With the increasing complexity of the grid and the number of real-time decisions that need to be made about it, IoT and machine learning will continue infiltrating utility companies and eventually lead to more self-sufficient, autonomous grids.

“Ideally, we would transition things into a real-time environment,” said the director of engineering for a large southwest U.S. utility. “With the machine learning, as it gets data fed in automatically and as we get more and more online devices, it will continually update its information from past performance and it will tie that learning into its forecasting and predictions.”

Of course, a completely autonomous grid is still a ways off, but utilities are moving in that direction. In the near-term expect to see:

- More customer- and third party-connected devices on the grid and within utilities
- An emphasis on real-time decision-making and bringing in the appropriate resources and technologies to make this happen
- Pilot projects focused on machine learning across organizations in areas like cybersecurity, MDM and distribution network management

Visions for the future of IoT and machine learning tools include:

- “In the future, we will see the introduction of complex algorithms and intelligent processing at lower levels of the asset infrastructure to improve automation and self-managing functions locally either between utility assets or within the equipment,” said Dr. John Vicente, Chief Architect and Director of Industrial and Energy Solutions, Architecture, Internet of Things Group at Intel Corporation.
- “One of the biggest things we’re going to get out of it is learning what we don’t know already. These systems are going to identify issues and opportunities that we’ve never even thought about looking for,” said Jim Taylor, Chief Technology Officer, Tucson Electric Power. “That’s the beauty of a machine being able to do it. If it can learn on its own, then we don’t have to tell it what to go look for. It’s going to go find things that we hadn’t even thought of and lead us to conclusions that we wouldn’t have reached on our own.”

# Recommendations



IoT and machine learning technologies are rolling into utilities and being adopted throughout their organizations. It is important for utilities to be ready to adopt them on a larger scale:

## Develop a strategy.

As we noted earlier, there is a lack of comprehensive and specific strategies for IoT and machine learning within utilities. How do we make the technologies less piecemeal and part of a much wider initiative?

“Often times, engagements are classified as what I would call ‘Skunk Works’ projects—maybe a couple of people involved with a lot of manual intervention to reach an objective with a very limited scope. Those items do not translate well into a sustainable enterprise deployment for with long-term value,” said SAS’s Mann.

Utilities should prepare their strategic plans now to be able to leverage IoT and machine learning effectively across their organizations.

## Strengthen change management.

Strategy is certainly critical, but implementing these technologies will introduce significant change in utilities. Much of the utility world is predicated on a centralized model with a human in the loop, but IoT and machine learning transforms that model. Utilities should be prepared to make changes to the core of how they do business, and prepare their employees for these changes.

As one utility noted, “The biggest impact will all be around change management. Much of what our utility thinks of today as analytics are reporting and regression. They don’t venture beyond that realm. For us, not only having to understand machine learning, but also all of these IoT technologies and the analytics that are derived from them in an effective manner, is going to be the biggest change. It’s not so much the technology, it’s what happens to the people and the structure that surrounds it.”

## Learn from and think like other industries.

To bring these next-generation capabilities to bear, utilities can also explore other industries and how they leverage IoT and machine learning. Even using different terminology can help change mindsets.

“We use the analogy of our sensors now being capable of ‘tweeting’ or ‘streaming’ to indicate how we intend to use the new paradigm on Internet communication rather than the old proprietary SCADA protocols,” said Thierry Godart, General Manager, Energy Solutions at Intel Corporation.

“Applications like Netflix, Yelp, and so forth make use of inferences and analytics to provide actionable data for consumers. Retail intelligence from crowdsourcing and machine learning of sentiment analysis are also interesting concepts to be applied to energy consumers.”

## Connect with other utilities.

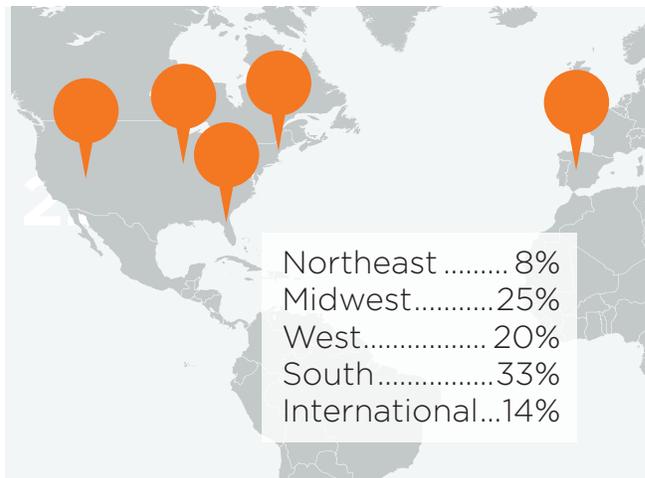
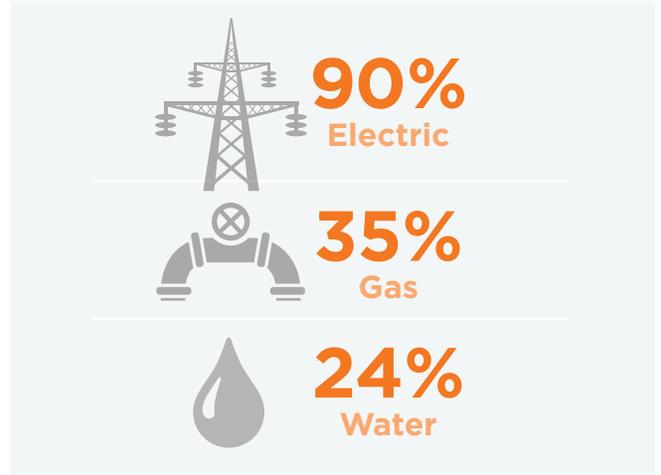
“I am a big believer of groups or forums,” said a survey respondent. “When we are exposed to new areas, we do not hesitate to call our colleagues who have been exposed to the issues we may be getting into.”

Utilities can benefit from connecting with other utilities to find out what’s working, what have been the challenges for others and how they worked through them, and then make certain that those key things are then continually addressed.

Are you ready to take IoT and machine learning to the next level within your organization? To learn more contact:

[www.sas.com/contact](http://www.sas.com/contact)  
[www.sas.com/iot](http://www.sas.com/iot)

Of the 200 utilities that participated in this study:



Top positions:

